

I/O magazine

ICT RESEARCH PLATFORM NEDERLAND

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IPN ICT-ONDERZOEK
PLATFORM
NEDERLAND

PAUL KLINT

Advisory college saves millions

Have you ever heard about AcICT? It has saved the Dutch taxpayer hundreds of millions of euros.

‘Adviescollege ICT Toetsing’ is the bureaucratic, PR-defeating name of an advisory college I have been serving on for the last seven years. AcICT’s goal: review plans for both new IT projects of the Dutch government and for maintenance projects. Since we will be delivering our hundredth advisory report soon, and I will leave the college by the end of this year, it is time for some reflection.

Originally, the Royal Netherlands Academy of Arts and Sciences asked me to represent the scientific view on software engineering in this college. Soon I discovered that the Achilles’ heel of this whole operation is common sense and not scientific insight. Quite a few projects miss a clear business case: it is unclear which problem is solved, who will benefit, and what the economic benefits will be. Case in point: an electronic toll collection system for a new tunnel where a back-of-the-envelope calculation shows that the toll collected during the expected lifetime of the tunnel would never pay back the total costs of development and maintenance.

Other project plans shout ‘innovation’ and want to completely replace existing ICT infrastructure with new technology. An excellent idea in a minority of cases and a recipe for failure in most others. The imperfections of the new technology are not yet known, experts are hard to find, and the transition between old and new infrastructure may become a nightmare or at least a source of huge cost overruns and delays.

Are there science-based approaches that could support AcICT? Yes, for example: (a) simulating policy decisions or law changes to estimate the impact on existing ICT; (b) natural language analysis of project plans, progress reports and email conversations to spot over-optimism, inconsistencies, and sentiments among managers as well as developers; (c) budget analysis to classify which budget entries are related to maintenance – the Dutch government does not know this; (d) analysis tools for version repositories, documentation, and source code.

Focussed research and open data efforts on these and other related topics may enable AcICT to save millions more euros still.

BUILDING AN INTERNET OF SECURE THINGS

An abstract network diagram with a dark blue background. It features numerous circular nodes of varying sizes, some of which are highlighted with a yellow-to-orange gradient. These nodes are interconnected by a complex web of thin, light blue lines. Several nodes are marked with a small padlock icon, indicating security or restricted access. The overall composition suggests a global or industrial network infrastructure.

T

While the Internet of Things is rapidly expanding, its security is lagging behind. The national research programme INTERSECT aims to provide solutions for the better design, defence, governance and privacy of connected devices.

By Bennie Mols

Images iStock, TU/e – Angeline Swinkels,
Sjoerd van der Hucht

In 2020, there were an estimated ten to twenty billion connected things worldwide, and this number excludes all our connected computers, smartphones and tablets. It merely represents devices in our homes like smart TVs, lights and thermostats, and things all around us, from smart surveillance cameras to connected cars, and from devices that make the electricity grid smart to devices that make greenhouse management more efficient.



Sandro Etalle

'IoT devices are much more difficult to secure and monitor than computers'

All these things are embedded with sensors, actuators and software for the purpose of exchanging data with other devices and systems over the internet. This ecosystem is referred to as the Internet of Things (IoT). The estimated numbers vary greatly, but by 2030 the Internet of Things will have grown to thirty to eighty billion devices worldwide.

While this creates many new opportunities, often in terms of increased efficiency, this new ecosystem unfortunately also leads to new security risks. IoT devices can be used to spy on us, launch massive, distributed cyber-attacks, infect networks, and start sophisticated nation-state attacks on crucial infrastructure.



Harold Weffers

'At the end of the day, INTERSECT is about having societal impact'

On top of these problems, geopolitical changes, like the rising power of China and Russia's invasion of Ukraine and its threats toward the Western world, make secure IoT even more urgent. EU countries must become less dependent on foreign markets and better protect themselves against IoT attacks.

Secure and monitor

The national research programme INTERSECT was launched in 2020 to better understand the security problems associated with IoT and to solve these. INTERSECT is an abbreviation for 'An Internet of Secure Things'. The

research programme runs for eight years, until the end of 2027, and received ten million euros in funding from the Dutch Research Agenda (NWA).

Scientific leader of the programme is Sandro Etalle, Professor of Cybersecurity at Eindhoven University of Technology (TU/e). 'With the Internet of Things, we face the power of computer science without many of the tools that have made computer science bearable in terms of security', says Etalle. 'The huge number of connected devices cannot be managed anymore one by one, like we used to do with standalone computers. They cannot even be maintained by system managers. IoT devices are much more difficult to secure and monitor than computers. They are used as stepping stones for new forms of cyber-attacks. Some devices are even left in the wild, unpatched, after a company has stopped manufacturing them or ceased to exist at all.'

Weak links

The Internet of Things poses so many security challenges that these can only be solved when researchers join forces with partners from industry, government and societal organisations. That is what INTERSECT does. The programme consists of five work packages that work closely together: design, defence, attack, governance of security and privacy, and the supporting Federated Lab. A secure Internet of Things needs better security design methods, ways of defence, understanding of possible ways of attack, regulation and an eye for the human users who often turn out to be the weak links in the chain of security measures.

Etalle's TU/e colleague Harold Weffers is the programme manager of INTERSECT. He explains its philosophy: 'The fundamental research is done at six universities. In addition, three universities of applied sciences, together with TNO, do the applied research. Our researchers work with partners from industry, government and societal organisations on concrete case studies, the validation of methods and sometimes on the development of products. At the end of the day, INTERSECT is about having societal impact. That makes a programme within the Dutch Research Agenda different from a traditional NWO programme.'

2021 was the first full year for INTERSECT, but due to the COVID-19 pandemic, collaborations within the programme were limited. However, the research started to take off. 'We will recruit a total of 27 PhD students, 11 of whom have already started', says Etalle. 'A crucial aspect of the programme is that they spend part of their time in a company to become familiar with the IoT security problems that companies have to deal with. That time will also give them the opportunity to validate their research in practice.' Although the 27 PhD students each have their own specific research challenge, INTERSECT aims to integrate all of the components. 'We want to combine the knowledge and experience of all parties', says programme manager Weffers. 'What are the common

characteristics of IoT in several application areas? Knowing that will allow you to work on generic solutions. We facilitate the integration of the research by holding regular meetings around the five work packages and organising a national meeting twice per year where we pick up input and report intermediate results.'

One of the industrial parties in INTERSECT is the company Verum Software Tools BV, which is based in Eindhoven. Verum develops a programming language based on formal methods. When used in the control part of an IoT device, it enables the software to be directly verified so that its correct functioning can be guaranteed.

Bert de Jonge is the CEO of Verum. 'We want to contribute to the "security by design" aspect of INTERSECT', he says. 'We develop software implementations that can be completely trusted, in terms of five aspects: safety, reliability, availability, resilience and security.' Versions of their software run, for example, on Philips X-ray scanners and high-tech microscopes of Thermo Fisher. Verum's programming language is open source so that everybody can check what is going on under the hood of the software. De Jonge hopes to further demonstrate the potential of their trustworthy software in a particular INTERSECT use case. De Jonge: 'I'm thinking of the key management problem that ProRail deals with. Trains run over track sections, and for each track section, a digital key is communicated between the train and a central platform. We would like to show that we can build software for which we can give a security guarantee that it is, by any practical means, impossible to break into.'

Which particular use cases INTERSECT is going to work on is still under consideration. This autumn, a workshop will be organised for the application domains smart energy and smart health. 'One important thing we will discuss there is a common terminology', says Weffers. 'What exactly do we consider to be an IoT device? Which security problems do we want to address and which not? How are we going to solve them? How can we ensure that external parties will adopt the security methodologies that we will develop? Crown jewels left lying around in a cupboard at a university do not help anyone.'

Projected results

The security problems of the Internet of Things are huge and incredibly diverse. The INTERSECT programme has just taken off and, to be honest, eight years is not that long. So what can be realistically achieved by the end of 2027? 'First of all', says Weffers, 'we can expect some new methodologies that will make the Internet of Things more secure. Second, I expect the programme to lay the foundations for a more systematic and strategic future approach to the problem of IoT security. INTERSECT will help us find solutions, but, of course, it will not be able to solve the problem for the entire world, let alone for the Netherlands as a country.'

Nevertheless, De Jonge wants to set the bar high: 'Some bigger companies like ASML or Philips have recognised the need for trustworthy software. My ambition is for this concept to be embraced far more widely, also by small and medium-sized enterprises.' But he also gives a warning that concerns the inherently very international aspect of IoT security: 'If we develop something that does well in the Netherlands, there are no guarantees that it

Bert de Jonge

'Crown jewels left lying around in a cupboard at a university do not help anyone'



will automatically be implemented elsewhere in the world, or even in Europe. Unfortunately, in the past, it was all too often the case that a company in the Netherlands developed some fine technology and was then subsequently bought by an American competitor. At some point in the INTERSECT programme, we will have to think about how we can safeguard what we do in the Netherlands for the rest of Europe.'

Scientific programme leader Sandro Etalle hopes that through INTERSECT, society will be able to design and manufacture IoT devices that are more under control and better to monitor. 'We currently have a black sea full of IoT devices. I will be very happy if INTERSECT could make this black sea more transparent without intruding upon the privacy of the users.'

INTERSECT IN BRIEF

Research themes: design, defence, attack, governance and privacy for the creation of a secure Internet of Things (IoT)

Duration: 8 years: 2020-2027

Budget: 9.94 million euros (provided entirely by NWO through the Dutch Research Agenda (NWA))

Partners: 48 (including: 6 universities, 3 universities of applied sciences (HBO), TNO, NWO-I, NSCR, Ministry of the Interior and Kingdom Relations, Consumentenbond, SURF, and companies (among them Philips, Canon Production Printing, Siemens and NXP Semiconductors))

Researchers: 27 PhD students, and a number of researchers from TNO and three universities of applied sciences

Application domains: Smart industry, Smart health, Smart energy, Smart mobility, Smart cities

Website: intersct.nl

EUROPEAN PLEA FOR SOFTWARE RESEARCH

By Sonja Knols Image iStock

**'SOFTWARE ENGINEERING
IS FAILING BOTH ON THE
MANAGEMENT SIDE AND
ON THE TECHNICAL SIDE'**

'Now is the time for aggressive funding of software research, and for leveraging the expertise that Europe has to offer, to remain autonomous and stay ahead of the curve.' That is the main message of a recent European petition signed by over 800 researchers, software developers and programmers.

'France and Finland harbour organisations resembling our Dutch association for software engineering research VERSEN. Both the French Groupement de Recherche Génie de la Programmation et du Logiciel (GDR GPL) and the Finnish Information Processing Association (TIVIA) had read the manifesto we published last December and contacted us to explore if we could issue a similar, joint statement at the European level', VERSEN chair and lead writer of the petition Tijs van der Storm explains how the document came about. 'Based on several meetings, we came up with a one-pager, requesting European and national funding agencies to acknowledge the importance of software for society and the need for increased funding of software research.'

INVISIBLE MOTOR

The hundreds of people who signed the petition originate from over 30 countries, almost half of which are outside the European Union. 'This reflects the fact that software research is a topic that many people acknowledge as important. Nevertheless, actual investments keep lagging behind,' Van der Storm concludes. The problem with software, he says, is that it is omnipresent yet invisible. 'Our current society runs on software. Paul Klint once referred to software as being society's invisible motor. In our petition, we use the metaphor of oxygen: all life on earth depends on it, but you are not aware of its presence unless it is lacking.'

Van der Storm illustrates the urgency with some examples: 'In the Netherlands, we have an advisory board for ICT assessment ('Adviescollege ICT-toetsing'). For every government ICT project exceeding a certain amount of money, they are required to publish an assessment report. Their assessments show that many of these projects fail, meaning that millions of taxpayers' money are going down the drain. Software engineering is failing both on the management side and on the technical side. The world is changing, leading to altering demands on software. The cost of owning software is exploding. Thorough software engineering research is needed to improve software quality and ensure affordability, correctness, reliability and maintainability of the systems that underlie the functioning of our society.'

BROAD AWARENESS

The text of the petition has been shared with policymakers all over Europe, ranging from the Dutch Minister for Digitalisation Alexandra van Huffelen, members of parliament and NWO to European Committee members. The aim is to broadly raise awareness of the importance and urgency of dedicated funding for software research. In this context, Van der Storm has a message for the Dutch ICT community at large as well: 'Sign up for the VERSEN newsletter to get up to speed with the latest developments and actively take part in discussions and initiatives to support our call to action. Let's jointly bring across the message that fundamental software research is indispensable to fully deliver on the promises of upcoming technologies like big data and artificial intelligence.'

Read the petition here:

ir.cwi.nl/pub/31390

The VERSEN manifesto can be found on:

www.versen.nl/contents/manifesto

GRANT FOR GPU RESEARCH

The Open Competition Domain Science-M programme is intended for innovative, high-quality, fundamental research and/or studies involving matters of scientific urgency. Anton Wijs from Eindhoven University of Technology has recently been awarded such an M-grant for his 'Avoiding disasters with graphics processors' project. Wijs will investigate how graphics processors can be used to analyse complex systems such as cars, planes and robots. The resulting techniques will make it possible to detect software bugs, assess the safety and economic risks related to such systems, and derive trajectories for robots and vehicles.

On 8 August 2022, a new round was opened within the programme. Applications can be submitted continuously until 31 July 2023 or until the 72nd proposal has been admitted in package 5, whichever comes first.

More information on www.nwo.nl/en/calls/open-competition-domain-science-m-0



ICT.OPEN 2023 AND ICT PRIZE

ICT.OPEN 2023 will take place on 19 and 20 April 2023. Mark these dates in your calendar to ensure you can participate in this annual event where the entire Dutch computer science community meets. One of the recurring items on the programme is the award ceremony for the Netherlands Prize for ICT Research. This prize is awarded annually by IPN in collaboration with NWO to recognise outstanding research in computer science. Candidates for this award can be nominated by anyone active in the ICT research field before 15 November 2022 via the Royal Holland Society of Sciences and Humanities (KHMW). All the information needed to submit a nomination can be found on www.khmw.nl.



SCIENCE WORKS!

On 6 July 2022, Marcel Levi presented the new NWO strategy 'Science works!' to Robbert Dijkgraaf, Minister of Education, Culture and Science. 'NWO has a responsibility to help make science work. The new strategy contains four building blocks that are crucial for a well-functioning system and corresponding ambitions that NWO will work towards in the coming years', Levi said. 'The Netherlands is doing very well, but we will have to keep working on a science system that optimally facilitates innovation and knowledge development. This also includes focusing on the safety of knowledge and scientists. We also want to help reduce the workload for researchers so they can use their time more economically. This is why several ambitions in the strategy aim to make things easier for them.' More information on www.nwo.nl/en/nwo-strategy-2023-2026

NEW DIRECTOR NWO DOMAIN SCIENCE

Tanja Kulkens has been appointed director of the NWO Domain Science (ENW) with effect from 1 September 2022. Kulkens has worked at NWO for 28 years and knows the entire organisation and NWO's domain ENW inside out. In 1994, after obtaining her PhD in Biochemistry & Molecular Biology at the VU University Amsterdam, she started as a policy officer at SON, one of the foundations of NWO at that time. She then quickly moved on to managerial positions, always within the exact and natural sciences. For the last five years, she has been head of Chemistry and Physics at ENW.



By Leendert van der Ent
Images iStock, Axini

MANAGING COMPLEXITY BY CLOSING THE FEEDBACK LOOP

IT is a type of engineering. There is, however, one big difference. IT isn't limited by physical parameters that will show obvious systemic flaws right away. Furthermore, important parts of testing are only carried out late during a project. That combination has become a recipe for problems now that IT projects are becoming increasingly complicated. Axini introduced automated consistency testing to manage complexity early on.

Complex IT projects carried out on schedule and within budget: that almost sounds too good to be true. 'In practice it's even better', says Machiel van der Bijl, CEO and founder of Axini in Amsterdam. 'During a project for a customer, our first-time-right project optimisation saved 54 percent on efforts and 60 percent in lead time. Prospects indeed consider this too good to be true. Ironically, they can more easily be persuaded with just a twenty to thirty percent possible gain.'

OPTIMISED TESTING

Regardless of the exact percentage – how can these benefits be achieved? A typical IT project workflow starts with requirements, followed by design. After this come code writing, integration of modules, acceptance and finally production/ operation. 'Requirements are often drawn up by domain experts in plain text. Developers have to translate these into a system – after little, if any, interaction with the domain experts', Van der Bijl explains. 'In the transmission to developers "Chinese whisper" problems occur. What did the experts really mean? What are the exact definitions of parameters? It becomes clear that you can't build what you haven't written down.'

Misunderstandings are only sorted out during the tests belonging to the integration or acceptance phases. Van der Bijl: 'Integration may prove that the system doesn't work. It often happens that weeks or months might elapse before the system runs stably after elaborate testing.'

This consumes 40 to 60 percent of the project budget against 10 percent for coding. That is why we say: shift left (in time – Ed.), says Van der Bijl. 'Create consistency during the initial project phases by using optimised testing through Model Based



System Engineering. We test the intended system's behaviour before any code has been written. The Axini modelling platform results in accurate and consistent requirements. These are not laid down in text, but in a model that you could regard as a CAD drawing of the software system.'

AUOMATED TESTING

Therefore, Axini stands for more than just an organisational approach. The heart of the matter is the Axini modelling platform that can interact with requirements. Van der Bijl: 'The platform input is subjected to machine reasoning, given certain constraints, resulting in a route planner for the automated test process.'

A conventional test process by hand will, as a consequence of limited example cases in terms of scope and number, not be able to cover all risks and create consistency. 'Machine reasoning on our platform is aimed at consistent requirements covering all risks', Van der Bijl says. The corporate IP lies in the trade-off between the infinite number of possible checks and a practicable, representative set of checks to work with in practice. 'Automated testing on our modelling platform prevents laborious reiterations through the entire workflow. It manages complexity by closing the feedback loop.'

To use an analogy: just like big data can no longer be overseen by humans and is therefore analysed by AI, projects have also become too complex to be covered by human testing and are therefore analysed by AI as well. The Axini platform helps to answer two fundamental questions: did we build the right thing, and did we build the thing right?

PROVEN CONCEPT

In the first ten years of its existence, Axini transformed an academic proof-of-concept into a usable engineering toolset. During the last five last years, it has proven that it works in projects for Achmea and Pensioenfonds Campina. Thermo Fisher (FEI) made use of it to manage the complexity of power electronics, optics and mechanics integration. And ProRail succeeded in introducing an important component of the safety-critical European railway digitalisation project ERTMS (the ETIS system) within schedule and budget thanks to Axini's help.

Now the time has come for further expansion. 'At the same time, we keep on innovating and improving', says Van der Bijl. This is done in collaboration with parties such as University of Amsterdam, Eindhoven University of Technology, University of Twente, ESI TNO, RI.SE (Sweden) and Fraunhofer (FOCUS). Van der Bijl: 'We still have the fundamental issue of checking our model with complex data. Many universities consider the model to be too large and complex to tackle. So we're keen to meet a party that is willing to take on this challenge.'



Machiel van der Bijl

**'WE TEST THE
INTENDED
SYSTEM'S
BEHAVIOUR
BEFORE ANY CODE
HAS BEEN
WRITTEN'**



Blending AI with cognitive science

By Bennie Mols Images Ivar Pel



GROUP PASSPORT

RESEARCH FIELDS

Computational linguistics, deep learning for perception, human-AI interaction, autonomous agents, robotics and gaming.

INSTITUTION

The Department Cognitive Science and Artificial Intelligence is part of the Tilburg School of Humanities and Digital Sciences at Tilburg University.

LABS

Virtual, mixed & augmented reality lab, Natural language and data processing lab, Robotics & avatars lab, Serious games & learning lab, DAF Technology Lab

EMPLOYEES (as of September 2022)

3 full professors, 38 assistant/associate professors, 4 lecturers, 4 postdocs, 19 (internal) PhD students

WEBSITES

www.tilburguniversity.edu/about/schools/tshd/departments/dca/lab

www.mind-labs.eu

icai.ai/masterminds-lab/

signon-project.eu

www.etz.nl/WeCare

Whereas AI research at Tilburg University gained prominence in the past through computational linguistics, the university's current AI research is strongly integrated with cognitive science. It focuses on topics such as deep learning architectures for multimodal data, human-AI interaction, and gaming and robotics.



Marie Postma

At first glance, artificial intelligence (AI) appears to be a hardcore computer science subject. It is no coincidence that AI is part of the computer science faculty at most universities. But at Tilburg University, AI is integrated with cognitive science and part of the Tilburg School of Humanities and Digital Sciences.

'Historically speaking, it is quite natural to combine AI and cognitive science', says head of the Department Cognitive Science and Artificial Intelligence, Marie Postma. 'When AI emerged as a discipline in the 1950s, traditional cognitive science themes inspired the goals of AI: machine translation, decision making and problem solving, modelling human intelligence in a machine. The development of neural networks, which are nowadays very successful, grew out of the idea of creating an electronic brain.'

Another reason why AI and cognitive science are blended in one department at Tilburg University is the university's focus on the social sciences, says Postma. 'As far as AI is concerned, we are focusing on research and applications of AI where the human user plays an active role or where the data come from humans. The combination bears fruit in attracting new researchers. When we ask new group members what attracted them to us, they most often mention the combination of AI and cognitive science.'

Coaching-oriented culture

Research in the department focuses on four main themes, with a lot of collaboration and overlap between them: computational linguistics, deep learning for perception, human-AI interaction, and autonomous agents, robotics and gaming.

Of these four, computational linguistics has the longest history in Tilburg, dating back to the 1980s. Postma: 'In the meantime, research within computational linguistics has become multimodal. Many of our projects no longer work with just speech and text data, but also with video data. For example, in the Horizon2020 project SignOn, we are investigating how to use machine translation to translate between sign and non-sign languages, facilitating communication between the deaf and hard-of-hearing and the hearing community.'

The department was established in 2017 and so the research group is still very much in the development phase. 'We have grown rapidly', says Postma. 'The majority of our researchers are between 30 and 45 years old. My ambition



Maryam Alimardani



Sharon Ong

is for young scientists to be able to develop their own research line, despite the fact that they have substantial teaching obligations. To achieve this goal, we have deliberately developed a non-hierarchical coaching-oriented culture. Through MindLabs, a partnership between knowledge institutions and other partners in the region, our young researchers can also become involved in a variety of projects such as the ICAI MasterMinds.'

VR training for pilots

The department is of an international nature, with about seventy percent of the people coming from abroad. Associate professor Maryam Alimardani, working in the Human-AI interaction group, is one of them. She spent thirteen years in Japan before coming to the Netherlands.

About the international flavour of the department, she says: 'We have our very own, diverse culture, which is open, inclusive and respectful. In Japan, I always remained a foreigner in a group dominated by Japanese, whereas I came from Iran. And although Dutch culture overall is very mixed and diverse, I hear from expats in other groups that the higher the number of Dutch in the group, the more rigid the group culture. In our group, we feel a sense of belonging from day one because the majority is from somewhere else.'

Alimardani works in the field of brain-computer interfaces. 'I collect human brain signals and translate them into infor-

mation about user experience during interaction with a social robot, a computer or virtual reality. In one of our projects, we collaborate with the Royal Netherlands Airforce. Via a headset, we collect brain activity from pilots who are trained in a virtual reality simulation. The goal is to monitor their workload and give personalised feedback during the training sessions.'

AI to help radiologists

Sharon Ong is an assistant professor in the same department, working in the Deep Learning for Perception group. Ong specialises in medical image analysis. She was educated in Australia and has been a research scientist in Singapore. 'I very much like the fact that the department is still under development. It gives more new opportunities compared to joining an established department.'

Ong is working on two projects that are a collaboration between the Elisabeth-TweeSteden Ziekenhuis (ETZ) in Tilburg and Tilburg University. The aim is for the results and conclusions from the various projects to be applied in practice. Ong: 'In one project, we are creating an AI tool to detect bone tumours and monitor their progress. In a second project, we use AI to predict a patient's cognitive functioning after a brain tumour has been removed. The second project, in particular, is a strong combination of cognitive science and AI. As an AI person, I work alongside cognitive science people. I want to develop and implement new AI tools that help radiologists and other medical practitioners to improve patient care.'



Nick Bezhanishvili (1978) obtained his master's degree in Mathematics with honours from Tbilisi State University (Georgia) in 2000 and his PhD in logic from the Institute for Logic, Language and Computation (ILLC), University of Amsterdam in 2006. He has been an assistant professor at the ILLC since 2014. He became chair of the VvL in 2021.

LOGICAL COMBINATION

Nick Bezhanishvili from the Institute for Logic, Language and Computation of the University of Amsterdam is president of the Dutch Association for Logic and Philosophy of the Exact Sciences (VvL). He explains why VvL joins IPN.

By Leendert van der Ent

Image Ivar Pel

What is logic exactly?

'Logic is the study of correct reasoning using formal methods and the formal study of methods. It is situated between the disciplines of mathematics, philosophy and computer science. Logic has been called "the calculus of computer science", since it is a central part of the foundations of computer science and its methods allow us to understand the scope and limitations of computing. For instance, we can prove that a question is impossible to be solved by an algorithm.'

How can logic and computer science strengthen each other in practice?

'Especially in the medical realm, applications of black box AI are regarded with great scepticism. The ability to explain why a particular medical intervention was executed – that may have resulted in certain (adverse) outcomes for the patient – is predominant for a plethora of reasons. We believe that a rule-based logic approach might help to provide the ability to explain. My own rather theoretical work on spatial logistics has connections to medical imaging that can have wide-ranging applications.'

What does the VvL do?

'The Dutch research community of logic is recognised as particularly innovative and world-leading. The VvL was established in 1947 by Evert Beth, Arend Heyting and Andreas van Melsen as the learned society representing this inter-

disciplinary community. Currently, we have about two hundred members who represent the community internally and also reach out to a more broadly interested public. Instruments for this are our master's thesis prizes and the annual virtual "logic at large" lectures aimed at a broader audience.'


Why did the VvL decide to join IPN?

'Logic is a crucial piece of theoretical computer science that we plan to represent within IPN. Given the recent surge of research in AI and the focus on methods that don't allow opening up a machine to see its inner workings, logical approaches stand for methods that enable a higher degree of control over models. An example of this is Explainable AI.'

What are the mutual benefits of integration?

'It's a two-way road. The logic community can help IPN to fill present knowledge gaps, for instance on the subjects of Explainable and Symbolic AI. It can also strengthen the important links to the disciplines of mathematics and philosophy. For the VvL, being represented via IPN is important for making our voice heard. The future will reveal to what heights we can push each other, but we are certain that the union will be mutually beneficial.'

More information on:
www.verenigingvoorlogica.nl



DEVELOPING SUBROUTINES FOR THE FUTURE QUANTUM COMPUTER

By Bennie Mols Image iStock

Quantum computing is hot, which brings with it the danger that people rush into applications and forget to work on the fundamentals. Maris Ozols, however, loves to work on these and is creating building blocks for future quantum software.

'If the crowd goes that way, man...I go the other way.' That's what the American jazz pianist and composer Thelonious Monk once said about his music. The same applies to the work of mathematician and computer scientist Maris Ozols, assistant professor at the University of Amsterdam and researcher at QuSoft and Centrum Wiskunde & Informatica (CWI).

Ozols works in the hot area of quantum computing and quantum information, which combines his interest in mathematics, computer science and physics. 'Quantum computing has recently received a lot of interest from industry', says Ozols, 'but the more it has advanced, the more crowded applied quantum research has become and the more I want to move away from concrete applications. I see it as my academic duty to go a different way and try to solve fundamental problems that are relevant to the field in the long run.'

In April 2020, Ozols started a Vidi project in which he is developing fundamental building blocks for quantum algorithms. Ozols: 'I am not creating algorithms for specific problems, but general techniques to build useful subroutines. Think about a subroutine for finding the number that occurs the most often in a list. This is called a majority vote. Within the Vidi project, I have developed a subroutine that solves the quantum version of the majority vote problem.'

In a paper of sixty pages, Ozols and his colleagues have outlined how the majority vote can be determined on a quantum computer. It is a highly mathematical paper which uses tools from representation theory. Ozols: 'We don't know yet for which specific quantum computing problem the subroutine will be useful, but it is very probable that there will be applications that require determining the quantum majority vote.'

Developing Lego blocks

A commercial quantum computer is still under development and quantum computers on the laboratory scale nowadays contain at most in the order of one hundred quantum bits. That is still far too few for solving interesting problems that cannot be solved on a classical computer. However, ideas for interesting problems that might be solved on a future quantum computer with thousands of quantum bits are manifold, from simulating chem-

ical reactions to solving optimization problems.

Ozols is preparing for that future: 'To solve these problems on a quantum computer, we will need a toolbox of different subroutines. Every subroutine is like a Lego block, and with many Lego blocks, you can build useful quantum algorithms.'

'IT IS MY ACADEMIC DUTY TO SOLVE FUNDAMENTAL PROBLEMS THAT ARE RELEVANT IN THE LONG RUN'

The future quantum programmer will need a lot of mathematics, says Ozols, as a warning for computer scientists. 'Too often, computer scientists have the idea that if they learn a little bit of quantum mechanics, they will also be able to program a quantum computer. But it is not that simple. Programming a quantum computer requires conceptually different thinking. At present, it is not even clear what constitutes a good, high-level programming language for a quantum computer. We are more or less at the assembly level. We don't have enough quantum algorithmic techniques yet. But once we have enough of them, we can try to discover common features and group them together. And from there, we can start building a true, high-level, quantum computer programming language.'

More information:

homepages.cwi.nl/~maris/

CONNECTING THEORY TO PRACTICE

The Intelligent Software & Algorithms Lab (ISA Lab) challenges students of universities of applied sciences to turn academic concepts into practical products. As a result, theoretical knowledge finds a useful application. Two lecturer-researchers from NHL Stenden University of Applied Sciences started the lab two years ago, and are now already looking back on successful projects.

By Amanda Verdonk
Images WAT ontwerpers

'Computer science is a unique field,' says lecturer-researcher Wouter Brinksma of NHL Stenden University of Applied Sciences. 'You can immediately put your design into practice. For example, someone who designs a bridge usually does not build it himself. In computer science, this is possible.'

At least, in theory. In practice, many ideas remain on the shelf. Brinksma and his colleague Gert Meijer both studied computer science at NHL Stenden, where they also started working as lecturer-researchers. They soon discovered the added value of academic knowledge, and in particular in connection with practical solutions that universities of applied sciences (HBOs in Dutch) can offer. They went to the universities where they followed master's programs to enquire about possible collaborations. Meijer: 'I boldly asked my thesis supervisors at Utrecht University (UU) whether they had developed algorithms that had not yet been implemented. They replied: "What a good idea, we come up with all kinds of things, but we usually don't implement them."' With this first cooperation, the ISA Lab was born, in which students from NHL Stenden are working on making theoretical concepts applicable.



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*'HBO students are
introduced to
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ANNOTATION TOOL

The first project together with Utrecht University is about geometric algorithms and will be completed in February next year. These algorithms detect where objects or people spend most of their time. This helps, for instance, to find a bird's nest, the hunting ground of a predator or the location of people in public spaces. Meijer: 'Scientists described this algorithm in a very mathematical and theoretical way. We first worked out the maths, and then students solved common deviations, also known as edge cases. The algorithm is now in an open source library and can be used by anyone to create tools.' And that is exactly what is happening – people at another university of applied sciences want to use the algorithms to investigate whether there is a correlation between tourist hotspots and damaged nature.

Brinksma also started looking for assignments for ISA Lab, and partnered up with the Open University (OU), where he is currently doing a master's degree. The OU participates in a European research project called QPED, which aims to improve the quality of software that students write. Brinksma: 'We implemented Procedural Guidance – a theoretical approach developed by the OU that helps students to think about quality assurance when writing software. Students often approach robustness by means of trial and error, but with this process, we take a more systemic approach.' To achieve this, students from the ISA Lab made an annotation tool that can be integrated into Visual Studio Code, a well-known programming tool. Now when the students start writing code, an extra window appears, which helps them to annotate smarter. In this tool, they describe the steps they are going to take and define the conditions of different parameters. Brinksma: 'The annotation tool helps the programmer by identifying test cases: Have you thought about this yet? Have you perhaps made a mistake here, or have you forgotten something there?' The tool is explicitly not aimed at automating the work and taking work off the students' hands. It is aimed at learning to program better by facilitating the thinking process. The tool is already in an advanced stage of development and there are currently talks with a software company that is considering integrating it in its online learning environment.



ABOUT ISA LAB

The Intelligent Software & Algorithms Lab (ISA Lab) was founded by NHL Stenden University of Applied Sciences in 2020 and aims to strengthen the collaboration between universities of applied sciences and academic universities in the field of ICT research. So far, seven research projects have been undertaken by seventeen students. External partners are Open University and Utrecht University.



CONCEPTUAL THINKING

'Collaborating with higher professional education is very useful to us', says Lex Bijlsma, emeritus professor of computer science at the OU. 'At the university, we only look at whether students can make something in principle, without implementation. The mathematician W.E. Milne once said, "A mathematician knows how to solve a problem but cannot do it". But HBO students can.' Also, Bijlsma thinks that HBO students can learn something from the academic way of thinking and working. 'Universities of applied science are used to working with companies as clients that come up with precise assignments and expected outcomes. We assign our students with a much more abstract description. They then have to figure out for themselves how to arrive at a practical product.' The ISA Lab is therefore particularly suitable for HBO students interested in academia and not afraid of theoretical concepts. Harrie Passier, assistant professor and project

leader of the QPED programme, adds: 'HBO students are introduced to conceptual thinking. That requires them to actively contribute ideas.' Bijlsma: 'It is essential to connect the two worlds of theory and practice. Good software is only created when designer and builder speak the same language.' The lab is a success, says Meijer. 'It works very well. Some students are doing additional projects and don't even want to leave.' New projects with the OU and the UU are now being explored, and the ISA Lab is also taking on some internal projects, for example to create a VR classroom and a visual programming language. Other universities are also showing interest. Moreover, a 'plus programme' such as the ISA Lab fits in with the current policy of universities of applied science that want to strengthen their research activities, as they also do with lecturer-researcher positions (lectorates). Brinksma: 'The lab shows nicely how collaboration between higher professional education and universities can take shape, and it positions the universities of applied science more strongly in the knowledge market.'

A WHOLE NEW WORLD OF POSSIBILITIES AND RISKS

By Amanda Verdonk Image iStock

Tech companies are working hard on creating a natural and lifelike experience in the metaverse.

The Netherlands can play a major role in this – not in the least by identifying and limiting the risks.

In the metaverse, you can move freely in virtual worlds – worlds that might look exactly like the real world, but could also be fantasy worlds in which, to name just one random example, you hop like a unicorn in a candy-pink fairy-tale forest. Omar Niamut, director of science at TNO's ICT unit, will not quickly turn into a unicorn, but is still a great 'believer', as he says himself, in the metaverse. Wearing a virtual reality (VR) headset, he attended several virtual events from his dining table. 'Even though I was at home, I felt like I was physically present and really met people. This was confirmed when I met one of them in person a year later. Video-conferencing does not give you such an experience.' Niamut has been working on eXtended Reality (XR) and immersive media technologies at TNO for many years; for example, he studied how to visually depict people in 3D as truthfully as possible. Not only to play lifelike games, but also to bring people together when that is not physically possible, and for educational, medical and

business purposes. Think of a shared journey through our solar system as a physics lesson, a virtual medical examination including physical touch, or a close look at an oil rig with a remote expert.

Hot topic

Since Facebook announced its name change to Meta last year, the metaverse has been hot. The company says it is not going to build the metaverse by itself but primarily wants to contribute to it. Science fiction writer Neal Stephenson coined the term metaverse. In his 1992 dystopian novel *Snow Crash*, users move through a virtual urban world as avatars, virtual representations of themselves. In this world, there are major class differences among the users, with some choosing to stay in the metaverse full-time. Recent well-known games such as *World of Warcraft*, *Fortnite* and *Roblox* also revolve around entering a virtual world, but from a 2D screen. 'They are not yet fully immersive. In the metaverse you can completely

DUTCH RESEARCH ON THE METAVERSE

Apart from TNO, there are many Dutch research groups that study extended reality, virtual reality, augmented reality and the metaverse. These include CWI, TU Delft, Utrecht University, VU Amsterdam, Amsterdam University of Applied Sciences, Leiden University, Rathenau Instituut and Mediacollege Amsterdam. Knowledge institutions and companies united in the Top Sector Creative Industry are working on a research proposal about Immersive Content for the National Growth Fund.

immerse yourself and feel present in the virtual experience.' The developers behind these games are, however, working on making them 'metaverse ready' and are developing building blocks for the metaverse.

While the metaverse is partly about the design of fictional or true-to-life virtual worlds, it depends on a backbone of many different types of hardware, which still require a lot of technical development. Firstly, of course, VR glasses demand good lenses, should prevent motion sickness, and should be pleasant to wear. A lifelike experience without delay also requires tremendous computing power. This calls for faster and more reliable computing networks, such as 6G. 'Artificial intelligence will also play a major role, for example by translating in real-time, so that we immediately understand the people we meet, even though they might speak a different language in real life.' A lifelike experience also depends on sensory development. This can be done with

gloves, a whole suit, but also with the help of sound waves, for example. Dutch companies play a major role in this. For instance, Senseglove from Delft makes a glove that lets you experience a real touch in a virtual environment, and Sensiks from Amsterdam makes cabins in which all the senses are stimulated with the help of heat, wind, smell, vibrations, light and sound. In the long run, we might even expand our own bodies with brain implants (brain-computer interfaces) and smart lenses so we no longer require large physical objects.

Opportunities and risks

As with many new technologies, the metaverse will probably not only provide us with new opportunities, such as viable alternatives to travel, and educational, medical and professional opportunities, but it will also entail risks. Will it become a commercial trap? Will the prediction in Snow

Crash prove to be true, where people get addicted to the metaverse and don't want to get out? Also, the dangers of *deepfakes* will become greater, Niamut thinks. 'Discussions will emerge about what is real. Do

'Society should determine how we experience reality'

we experience the same reality? We must ensure that metaverse platforms are designed in such a way that society determines how we experience reality.' Niamut is therefore a believer but does not close his eyes to the risks. 'We are at the starting point of a new development; companies are investing heavily in this. That is why it is all the more important that we also help to develop this in the Netherlands, with our own standards and values in mind.'



Caroline Gevaert was born in the United States, studied International Land and Water Management at Wageningen University, worked in Bolivia and obtained master's degrees in Spain and Sweden. She obtained her PhD at the University of Twente for her research on the use of drones and AI in African slums. She is now an assistant professor at the Earth Observation Science department of the University of Twente. She is also a GIS advisor at the World Bank and has been a member of the Young Academy of the KNAW since March this year.

LOOKING OUT FOR EVERYONE

By Leendert van der Ent Image Gijs van Ouwerkerk

For Caroline Gevaert from the University of Twente, inclusiveness is crucial. Not only for the use of AI in geo-informatics, but also in the scientific community.

'Buildings in developing countries look different from those in western countries. I analyse images collected by satellites and drones to determine, for example, if a building is a house, a hut, a tent or a shed. In my work, I increasingly make use of artificial intelligence. That is why I study the ethical aspects of AI in geo-informatics, which is still in its infancy. However, as in other fields, bias may also occur here. Algorithms work better for wealthier areas, where more data is available. As a result, vulnerable groups might be overlooked. When a natural disaster such as a flood occurs, they remain without humanitarian aid.

By explaining the results of automated mapping to the users, we hope that these results will be better implemented. I think it is important to communicate clearly about the strengths and weaknesses of algorithms. If you don't, and you use them for purposes they weren't designed for, it can lead to wrong decision-making. AI is playing an increasingly important role in my field, but its use is not always necessary. I sometimes feel that we are very busy improving small percentages of accuracy, while this has limited added value for the final use.'

COMBINING JOBS

'In addition to my academic work, I am also a consultant at the World Bank for two days a week. My experiences at the World Bank help me to adjust my research and build a broad network. I would recommend such a combination to everyone, but I do realise that it is hard for young researchers to achieve this. If you are working to become an assistant professor, you get more responsibilities and publishing pressure and are expected to participate in more projects. And it is often also the phase in which you have children. But I want to show that it is possible.

I recently became a member of the Young Academy of the KNAW. Within that role, I want to work harder for inclusiveness. I want to do research not only about but also with developing countries and consciously seek collaboration with people from different fields. For example, I have contacted a South African philosopher about the possibility of working with me, and I arrange funds for young researchers to visit international conferences. But I still need to think more about how I want to shape my ambitions in this area.'